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**To: Sarah Dunham and Mary Jo Krolewski, EPA**

**From: Barry Galef, John Powers, and Jia Li, ICF**

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**Re: NO<sub>x</sub> Allowance Allocation Methods**

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## **OVERVIEW**

In total, nine NO<sub>x</sub> allowance allocation methods are described. One method (Option 0) mirrors the optional method presented in the SIP Call Final Rule. Three more (Option 1, 2, and 3) represent additional methods proposed in the October 21, 1998 section 126 proposal. The rest (Option 1A, 1B, 1C, 2A, and 2B) are variants of the preceding methods, and are included for comparison.

The major characteristics of each method are as follows:

**Option 0: (the method recommended in the SIP Call):** historical fuel input for fossil-fueled units for the first three years from 2003 to 2005, then switching to an annual updating fuel input system thereafter;

**Option 1:** historical fuel-input-based, for fossil-fuel units;

Option 1A: historical electricity output-based, for fossil-fuel units;

Option 1B: historical electricity output-based for all sources

Option 1C: historical input-based, however 2% of the allowances would be taken away annually for auction;

**Option 2:** annual updating output-based, for fossil-fuel units, with a four-year lag;

Option 2A: annual updating fuel-input-based, for fossil-fuel units, with a four-year lag;

Option 2B: quadrennial updating output-based, for fossil-fuel units, with a four-year lag;

**Option 3:** annual updating output-based, for all sources, with a four-year lag;

The basic characteristics, assumptions, and equations for allowance allocation calculations for each method are explained in the following sections. It should be noted that the fuel input and electricity output discussed in the following sections refer to the input and output during the ozone season (or, control period) within the affected region (i.e., the region covered by the October 21, 1999 section 126 proposal) only.

**Option 0: Historical fuel-input of fossil-fuel units for the first three years from 2003 to 2005, switching to an annual updating fuel input system thereafter**

(This method reflects the optional allocation method in the NO<sub>x</sub> SIP Call Final Rule promulgated by EPA in October 1998)

Characteristics

1. Allowances allocated to fossil fuel units only;
2. Allowances allocation based on the fuel input of the fossil fuel units;
3. Allowances allocation based on the historical fuel input (1995, 1996, and 1997) for the first three years from 2003 to 2005, and switch to an annual updating system thereafter;
4. For the first three years of implementation (2003-05), each unit would be allocated allowances based on historical fuel input between 1995 and 1997. Starting in 2006, the allowances allocated in Year T are updated annually based on the fuel input during the ozone season in year (T-4);
5. A unit would lose allowances several years after it was shut down; and
6. New units would be allocated allowances from a set-aside on a first-come first-serve basis. For the first four years upon commencement, a new unit would be allocated allowances based on their fuel input during the ozone season in that year. Starting in the fifth year, the unit would be integrated into the updating system and the allowances allocated in Year T are updated annually based on the fuel input during the ozone season in Year (T-4). Five percent of the allowances would be set aside from the allowance pool between 2003 and 2005, and 2% would be set aside thereafter.

Assumptions

Emission factor = 0.15 lb of NO<sub>x</sub> / mmBtu of fossil fuel

Calculation equations

2003-2005:

$$A_{i,T} = \frac{[\text{sum } (q)_{1995-97} - \min (q)_{1995-97}]_i}{2} \times \frac{0.15}{2,000} \times 0.95$$

2006 and beyond:

$$A_{i,T} = q_{i,(T-4)} \times \frac{0.15}{2,000} \times 0.98$$

New units in the first four years upon commencement:

$$A_{i,T} = q_{i,T} \times \frac{0.15}{2,000}$$

Where  $A_i$  is allowances in tons of NO<sub>x</sub> allocated to unit i

T is the year that allowances are allocated

q is the fuel input in mmBtus during the ozone season

2,000 is the number of pounds per ton

If the total allowances allocated to all units are more or less than the total number of allowances available, the allocations would be adjusted up or down among units in proportion to the number allocated, to ensure that the total number of allowances allocated equaled the total number available.

### **Option 1: Historical Input Approach for Fossil Fuel Units**

#### Characteristics

1. Allowances allocated to existing fossil-fuel units only;
2. Allowances allocation based on the fuel input of the fossil fuel units;
3. Allowances allocation based on the historical fuel input during the ozone season in 1995, 1996, and 1997;
4. The average of two maximum fuel inputs during the ozone season in 1995, 1996 and 1997 is the basis of allowances calculation;
5. Allowances allocated to each unit would be constant each year and a unit would not lose allowances when it was shut down;
6. New units would not be allocated allowances.

#### Assumptions

Emission factor = 0.15 lb of NO<sub>x</sub> / mmBtu of fossil fuel

#### Calculation equations

$$A_{i,T} = \frac{[\text{sum } (q)_{1995-97} - \min (q)_{1995-97}]_i}{2} \times \frac{0.15}{2,000}$$

Where  $A_i$  is allowances in tons of NO<sub>x</sub> allocated to unit i  
T is the year that allowances are allocated  
q is the fuel input in mmBtus at unit i during the ozone season  
2,000 is the number of pounds per ton

If the total allowances allocated to all units are more or less than the total number of allowances available, the allocations would be adjusted up or down among units in proportion to the number allocated, to ensure that the total number of allowances allocated equaled the total number available.

**Option 1A: Historical Output Approach for Fossil Fuel Units**

*Differs from Option 1 only in that output is used instead of input*

Characteristics

1. Allowances allocated to existing fossil-fuel units only;
2. Allowances allocation based on the electricity output of the fossil fuel units;
3. Allowances allocation based on the historical electricity output during the ozone season in 1995, 1996, and 1997;
4. The ratio of the two maximum electricity outputs of the unit to the two maximum total electricity outputs of all fossil-fuel units during the ozone season in 1995, 1996 and 1997 is the basis of allowances allocation;
5. Allowances allocated to each unit would be constant each year and a unit would not lose allowances when it was shut down;
6. New units would not be allocated allowances.

Assumptions

Total allowances (A) = 530,329 (tons of NO<sub>x</sub>)

Calculation equations

$$A_{i,T} = A \times \frac{[\text{sum}(Q)_{1995-97} - \min(Q)_{1995-97}]_i}{[\text{sum}(Q)_{1995-97} - \min(Q)_{1995-97}]_{\text{all fossil units}}}$$

Where  $A_i$  is the allowances in tons of NO<sub>x</sub> allocated to unit i

T is the year that allowances are allocated

Q is the electricity output in kWh during the ozone season

### Option 1B: Historical Output Approach for All Sources

*Differs from Option 1A only in that it provides allowances for all sources, not just fossil fueled sources*

#### Characteristics

1. Allowances allocated to all existing electricity generating units;
2. Allowances allocation based on the electricity output of all units;
3. Allowances allocation based on the historical electricity output during the ozone season in 1995, 1996, and 1997;
4. The ratio of the two maximum electricity outputs of the unit to the two maximum total electricity outputs of all units during the ozone season in 1995, 1996 and 1997 is the basis of allowances allocation;
5. Allowances allocated to each unit would be constant each year and a unit would not lose allowances when it was shut down;
6. New units would not be allocated allowances.

#### Assumptions

Total allowances (A) = 530,329 (tons of NO<sub>x</sub>)

#### Calculation equations

$$A_{i,T} = A \times \frac{[\text{sum}(Q)_{1995-97} - \min(Q)_{1995-97}]_i}{[\text{sum}(Q)_{1995-97} - \min(Q)_{1995-97}]_{\text{all units}}}$$

Where  $A_i$  is the allowances in tons of NO<sub>x</sub> allocated to unit i

T is the year that allowances are allocated

Q is the electricity output in kWh during the ozone season

**Option 1C: Historical Input Approach for Fossil Fuel Units with 2% Taken Away for Auction Each Year**

*Differs from Option 1 only in that a growing fraction of allowances are auctioned each year*

Characteristics

1. Allowances allocated to existing fossil-fuel units only;
2. Allowances allocation based on the fuel input of the fossil fuel units;
3. Allowances allocation based on the historical fuel input during the ozone season in 1995, 1996, and 1997. However, 2% of the allowances allocated to the unit would be taken away to be auctioned by EPA each year.
4. The average of two maximum fuel inputs during the ozone season in 1995, 1996 and 1997 is the basis of allowances calculation;
5. The unit would not lose allowances when it was shut down; and
6. New units would not be allocated allowances.

Assumptions

Emission factor = 0.15 lb of NO<sub>x</sub> / mmBtu of fossil fuel

Calculation equations

$$A_{i,T} = \frac{[\text{sum}(q)_{1995-97} - \min(q)_{1995-97}]_i}{2} \times \frac{0.15}{2,000} \times (1 - 0.02 \times (T - 2003))$$

Where  $A_i$  is allowances in tons of NO<sub>x</sub> allocated to unit i

T is the year that allowances are allocated

q is the fuel input of the unit in mmBtus during the ozone season

2,000 is the number of pounds per ton

0.02 is the annual increase in the percentage that is taken away for auction

## Option 2: Output Updating Approach for Fossil Fuel Units

### Characteristics

1. Allowances allocated to fossil fuel units only;
2. Allowances allocation based on the electricity output of the fossil fuel units;
3. Allowances allocation updated annually;
4. Allowances in Year T are allocated to each existing unit from the allowance pool in proportion to its share of all fossil-fueled electricity output during the ozone season in Year (T-4);
5. A unit would lose allowances several years after it was shut down, as a consequence of the updating mechanism;
6. New units would be allocated allowances from a set-aside on a first-come first-serve basis. For the first four years upon commencement, a new unit would be allocated allowances based on their fuel input during the ozone season in that year. Starting in the fifth year, the unit would be integrated into the updating system and the allowances allocated in Year T are allocated to the unit from the allowance pool in proportion to its share of all fossil-fueled electricity output during the ozone season in Year (T-4). Five percent of the allowances would be set aside from the allowance pool between 2003 and 2005, and 2% would be set aside thereafter.

### Assumptions

Total allowances (A) = 530,329 (tons of NO<sub>x</sub>)

### Calculation equations

2003-05:

$$A_{i,T} = A * 0.95 * Q_{i,(T-4)} / Q_{all \text{ fossil fuel units, } (T-4)}$$

2006 and beyond:

$$A_{i,T} = A * 0.98 * Q_{i,(T-4)} / Q_{all \text{ fossil fuel units, } (T-4)}$$

Where  $A_i$  is allowances in tons of NO<sub>x</sub> allocated to unit i

T is the year that allowances are allocated

Q is the electricity output in kWh during the ozone season



## Option 2A: Input Updating Approach for Fossil Fuel Units

*Differs from Option 2 only in that it updates on the basis of fuel input, rather than output*

### Characteristics

1. Allowances allocated to fossil fuel units only;
2. Allowances allocation based on the electricity input of the fossil fuel units;
3. Allowances allocation updated annually;
4. Allowances in Year T are allocated to each existing unit from the allowance pool in proportion to the ratio of its fuel input to all fossil fuel inputs during Year (T-4);
5. A unit would lose allowances several years after it was shut down, as a consequence of the updating mechanism;
6. New units would be allocated allowances from a set-aside on a first-come first-serve basis. For the first four years upon commencement, a new unit would be allocated allowances based on its fuel input during the ozone season in that year. Starting in the fifth year, the unit would be integrated into the updating system and the allowances allocated in Year T are allocated to the unit from the allowance pool in proportion to its share of fuel inputs of all fossil fuel units during the ozone season in Year (T-4). Five percent of the allowances would be set aside from the allowance pool between 2003 and 2005, and 2% would be set aside thereafter.

### Assumptions

Emission factor = 0.15 lb of NO<sub>x</sub> / mmBtu of fossil fuel  
 Total allowances (A) = 530,329 (tons of NO<sub>x</sub>)

### Calculation equations

$$2003-05: A_{i,T} = A \times 0.95 \times \frac{q_{i,(T-4)}}{q_{all\ fossil\ units,(T-4)}}$$

$$2006\ and\ beyond: A_{i,T} = A * 0.98 * q_{i,(T-4)} / q_{all\ fossil\ units, (T-4)}$$

New units in the first four years upon commencement:

$$A_{i,T} = q_{i,T} \times \frac{0.15}{2,000}$$

Where  $A_i$  is the allowances in tons of NO<sub>x</sub> allocated to unit i  
 T is the year allowance is allocated  
 q is the fuel input in mmBtus during the ozone season  
 2,000 is the number of pounds per ton.

## Option 2B: Quadrennial Updating Output-based Approach for Fossil Fuel Units

*Differs from Option 2 only in that the allowance allocation is updated every four years, instead of annually.*

### Characteristics

1. Allowances allocated to fossil fuel units only;
2. Allowance allocation based on the electricity output of the fossil fuel units;
3. Allowance allocation updated every four years;
4. Allowances in Years T, T+1, T+2, and T+3 are allocated to each unit from the allowance pool in proportion to its share of electricity output of all fossil fuel units during the ozone seasons of Years (T-6, T-5, T-4, and T-3);
5. A unit would lose allowances several years after it was shut down, as a consequence of the updating mechanism;
6. New units would be allocated allowances from a set-aside on a first-come first-serve basis. For the first six years upon commencement, a new unit would be allocated allowances based on its fuel input during the ozone season in the year of commencement. Starting in the seventh year [or should correspond a new 4-yr period for existing units], the unit would be integrated into the updating system and the allowances allocated in Years T, T+1, T+2, and T+3 are allocated to the unit from the allowance pool in proportion to its share of electricity output of all fossil fuel units during the ozone seasons of Years (T-6, T-5, T-4, and T-3). Five percent of the allowances would be set aside from the pool from 2003 to 2005, and 2% would be set aside thereafter.

### Assumptions

Total allowances (A) = 530,329 (tons of NO<sub>x</sub>)

### Calculation equations

The allowances are allocated based on the following calculation equations, and the allowances are updated every four years:

2003-2006:

$$A_{i,T} = A \times 0.95 \times \frac{\sum_{1997}^{2000} Q_i}{\sum_{1997}^{2000} Q_{\text{all fossil units}}}$$

2007-2010:

$$A_{i,T} = A \times 0.98 \times \frac{\sum_{2001}^{2004} Q_i}{\sum_{2001}^{2004} Q_{\text{all fossil units}}}$$

(and similarly for 2011-2014, 2015-2018, etc.)

Where  $A_i$  is the allowances in tons of NO<sub>x</sub> allocated to unit  $i$   
T is the year that allowances are allocated  
Q is the electricity output in kWh during the ozone season

### Option 3: Output Updating Approach for All Sources

#### Characteristics

1. Allowances allocated to all electricity generating units;
2. Allowances allocation based on the electricity output of all units;
3. Allowances allocation updated annually;
4. Allowances in Year T are allocated to each existing unit from the allowance pool in proportion to its share of total electricity output of all units during the ozone season in Year (T-4);
5. A unit would lose allowances several years after it was shut down, as a consequence of the updating mechanism;
6. New units would be allocated allowances from a set-aside on a first-come first-serve basis. For the first four years upon commencement, a new unit would be allocated allowances based on their fuel input during the ozone season in that year. Starting in the fifth year, the unit would be integrated into the updating system and the allowances allocated in Year T are allocated to the unit from the allowance pool in proportion to its share of all fossil-fueled electricity output during the ozone season in Year (T-4). Five percent of the allowances would be set aside from the allowance pool between 2003 and 2005, and 2% would be set aside thereafter.

#### Assumptions

Total allowances (A) = 530,329 (tons of NO<sub>x</sub>)

#### Calculation equations

2003-05:

$$A_{i,T} = A * 0.95 * Q_{i,(T-4)} / Q_{all\ units,(T-4)}$$

2006 and beyond:

$$A_{i,T} = A * 0.98 * O_{i,(T-4)} / O_{all\ units,(T-4)}$$

Where  $A_i$  is allowances in tons of NO<sub>x</sub> allocated to unit i

T is the year allowance is allocated

Q is the electricity output in kWh during the ozone season